

Claims

1. A process for producing olefin polymers in the presence of a catalytic system in a continuously operated multistage polymerisation sequence, wherein an olefin monomer is polymerised first in slurry phase in a hydrocarbon diluent or liquid monomer, in at least one loop reactor, the slurry having a first concentration of solids, and then subsequently in gas phase in at least one gas phase reactor, said process comprising
 - continuously withdrawing from the loop reactor a polymer slurry containing polymer and a fluid phase, further containing hydrocarbons and optionally hydrogen,
 - concentrating the slurry by removing a part of the fluid phase to provide a concentrated slurry,
 - conducting the concentrated slurry having a second concentration of solids, which is higher than the first concentration of solids, to a high pressure flash unit in order to remove essentially all of the remaining fluid phase and to provide a product flow containing a suspension of polymer solids and gases, and
 - feeding the product flow of the flash unit into the gas phase reactor,wherein the receiving vessel of the flash unit is operated at a pressure of 10 to 30 bar, the operating pressure of the flash unit being higher than the pressure in the gas phase reactor.
2. The process according to claim 1, wherein the solids content of the concentrated slurry is 30 to 55 %, preferably 40 to 52 % by volume.
3. The process according to claim 1 or 2, wherein the slurry is concentrated by using a hydrocyclone or a sieve.
4. The process to claim 3, wherein the slurry is concentrated in a hydrocyclone to provide an underflow, which comprises the concentrated slurry, and an overflow, which is rich in hydrocarbon(s).
5. The process according to claim 1, wherein the slurry is withdrawn from the loop reactor in such a manner that the concentration of solids at the outlet is higher than the concentration of solids in the loop reactor.

6. The process according to claim 5, wherein the overflow is recycled to the loop reactor.
7. The process according to claim 6, wherein the ratio of the recycled overflow to the underflow withdrawn from the hydrocyclone is 0.01 to 10, preferably 0.01 to 5 and in particular 0.1 to 2.
8. The process according to any of claims 5 to 7, wherein the solids concentration of the slurry of the overflow is 0.001 to 5 % by volume of the flow.
9. The process according to any of the preceding claims, wherein the flash unit comprises a flash pipe, which is optionally heated, in which the remaining hydrocarbons of the concentrated slurry are at least partly evaporated to form an overflow containing the evaporated fluid phase, and a receiving vessel to form an overflow containing the evaporated fluid phase and a product flow containing the polymer particles and a minor amount of the fluid phase.
10. The process according to any of the preceding claims, wherein the receiving vessel of the flash unit is operated at a pressure of 12 to 27 bar, preferably 14 to 24 bar.
11. The process according to any of the preceding claims, wherein the receiving vessel of the flash unit is operated at a pressure, which is at least 0.05 bar higher, than the pressure in the gas phase reactor.
12. The process according to claim 9, wherein the flash pipe is heated with steam or water so that temperature of the gas at the receiving vessel is 50 to 100 °C, preferably 60 to 90 °C, in particular 70 to 90 °C.
13. The process according to claim 12, wherein the flash pipe is heated with water taken from a jacket of the loop reactor.
14. The process according to any of claims 11 to 13, wherein the overflow from the flash is recycled into the loop reactor or conducted to the gas phase reactor or both.

15. The process according to any of the preceding claims, wherein the product flow of the flash unit is flushed counter-currently in a gas exchange zone with an essentially hydrogen-free gas fraction to reduce the amount of hydrogen carryover to the gas phase reactor before the product flow is transferred into the gas phase reactor.

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16. The process according to claim 15, wherein the gas exchange zone comprises a conduit interconnecting the receiving vessel of the flash unit and the gas phase reactor and equipped with a control valve, whereby flush gas is introduced upstream and/or downstream of the control valve.

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17. The process according to claim 15, wherein the gas exchange zone comprises a conduit interconnecting the receiving vessel of the flash unit and the gas phase reactor and equipped with one or several rotary feeders, whereby flush gas is introduced upstream and/or downstream of the rotary feeder(s).

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18. The process according to any of the preceding claims, wherein the product flow from the flash unit contains less than 0.1 mol-% of hydrogen.

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19. The process according to any of the preceding claims, wherein the polymer is conducted into the gas phase reactor by gravity drop.

20. The process according to any of the preceding claims, wherein the gas phase reactor is operated at a temperature of 60 – 115 °C, preferably 70 – 110 °C.

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21. The process according to any of the preceding claims, wherein the gas phase reactor is operated at a pressure of 10 – 30 bar, preferably 15 – 25 bar.

22. The process according to any of the preceding claims, wherein the monomer is ethylene, which is optionally copolymerised with one or more C₄ to C₁₀ alpha-olefins.

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23. The process according to any of the preceding claims, wherein the catalytic system comprises a Ziegler-Natta catalyst, single site catalyst, multi site catalyst or a combination or mixture of the above.

24. An apparatus for producing an olefin polymer in the presence of a catalytic system, said apparatus comprising, in a cascade, a loop reactor, a hydrocyclone, a high-pressure flash and a gas phase reactor.

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25. The apparatus according to claim 24, further comprising a gas exchange zone arranged in the cascade between the high-pressure flash and the gas phase reactor.

26. The apparatus according claim 24, comprising

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- a loop reactor for polymerising olefin monomer in slurry phase in a reaction mixture comprising fluid hydrocarbons and optionally hydrogen and polymer particles and provided with at least one outlet to allow for continuous withdrawal of polymer slurry,
- at least one hydrocyclone having at least one inlet for the polymer slurry and at least one first outlet for concentrated slurry and at least one second outlet for an overhead flow, said inlet being connected to the outlet of the loop reactor, and said hydrocyclone being adapted to separate the fluid phase from the polymer slurry to provide a concentrated slurry,

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- a high pressure flash unit having at least one inlet for the slurry and at least one first outlet for a suspension of polymer solids and gases and at least one second outlet for evaporated fluid phase, said inlet being connected to the first outlet of the hydrocyclone, and said flash unit being adapted to separate the fluid phase from the concentrated slurry, and

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- a gas phase reactor having at least one inlet for polymer solids and gases and at least one outlet for polymer product, said inlet being connected to the first outlet of the high pressure flash unit.

27. The apparatus according to claim 26, wherein the outlet of the loop reactor is placed at a suitable location downstream of the loop circulation pump.

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28. The apparatus according to claim 24, wherein a gas exchange zone is arranged between the high pressure flash unit and the gas phase reactor to provide for countercurrent flushing of the product flow with essentially hydrogen-free gas.

29. The apparatus according to claim 28, wherein the gas exchange zone comprises a conduit interconnecting the receiving vessel of the flash unit and the gas phase reactor and equipped with a control valve, whereby flush gas can be introduced upstream and/or downstream of the control valve.

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30. The apparatus according to claim 28, wherein the gas exchange zone comprises a conduit interconnecting the receiving vessel of the flash unit and the gas phase reactor and equipped with one or several rotary feeders, whereby flush gas can be introduced upstream and/or downstream of the rotary feeder(s).